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US 4593197 A

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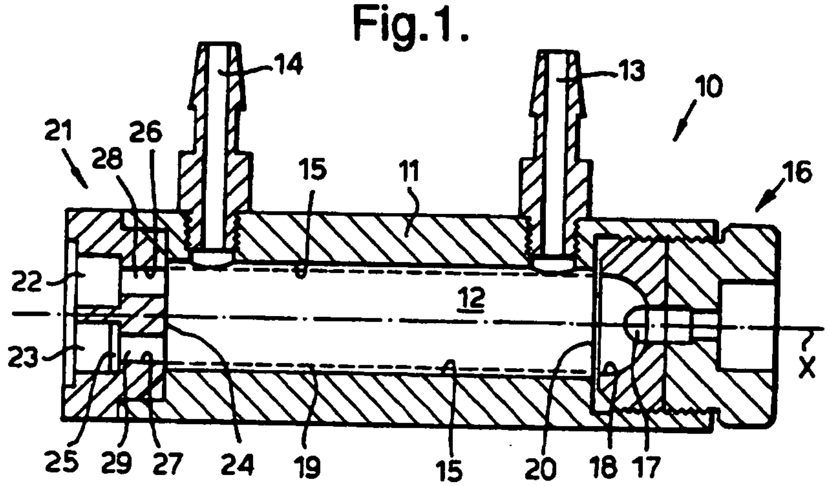
(54) Gas sensor detecting only non-reflected light

(57) Radiation emitted from a bulb 17 is reflected along a light path 19 by a reflector 18, through a window 20 of a chamber 12, and on through another window 24. Radiation is detected behind filter window 24 by an absorbance detector 22 and reference detector 23 inset in recessed passages 28, 29.

The internal face 15 of the chamber 12 are arranged to reflect substantially no radiation and radiation inhibitors 27, 28 are arranged to restrict reflective radiation entering recessed passages 28, 29.

When a gas is present within the chamber 12 it absorbs radiation emitted from the bulb 17 over a particular wavelength and the absorbance detector 22 is arranged to monitor variations in radiation over that wavelength.

Fig.1.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.

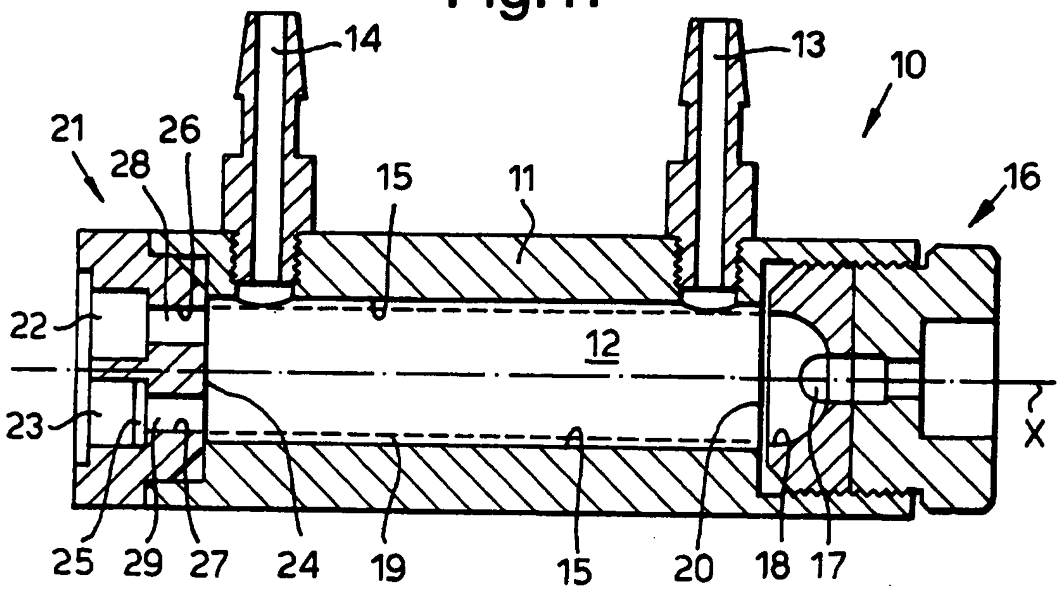
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Fig.2.

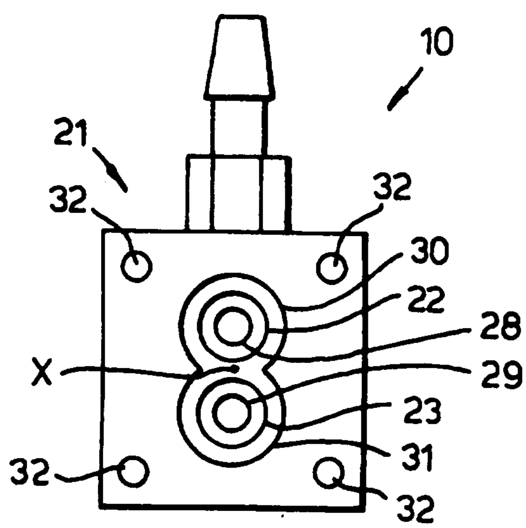
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Fig.3.

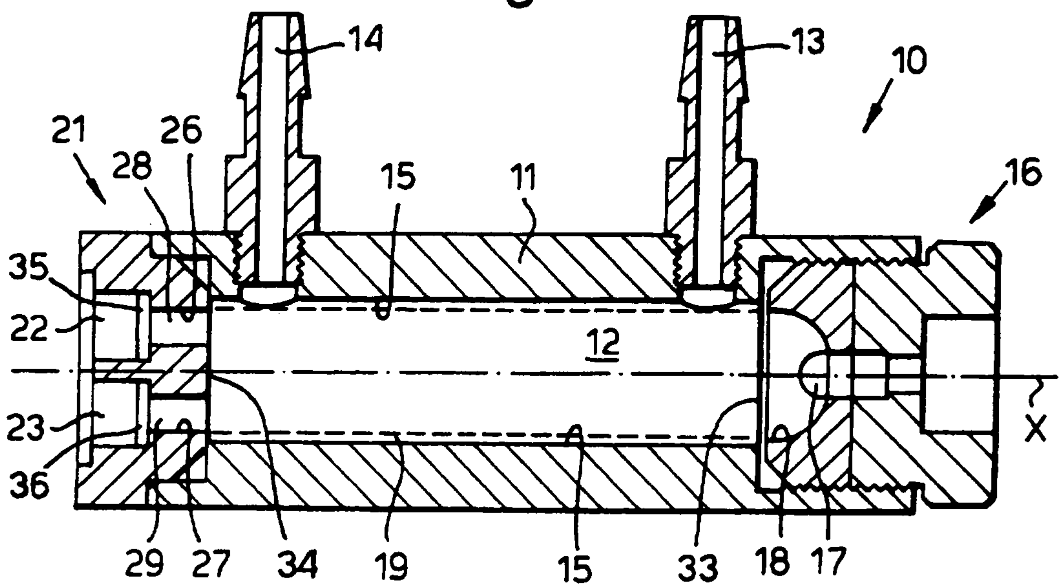
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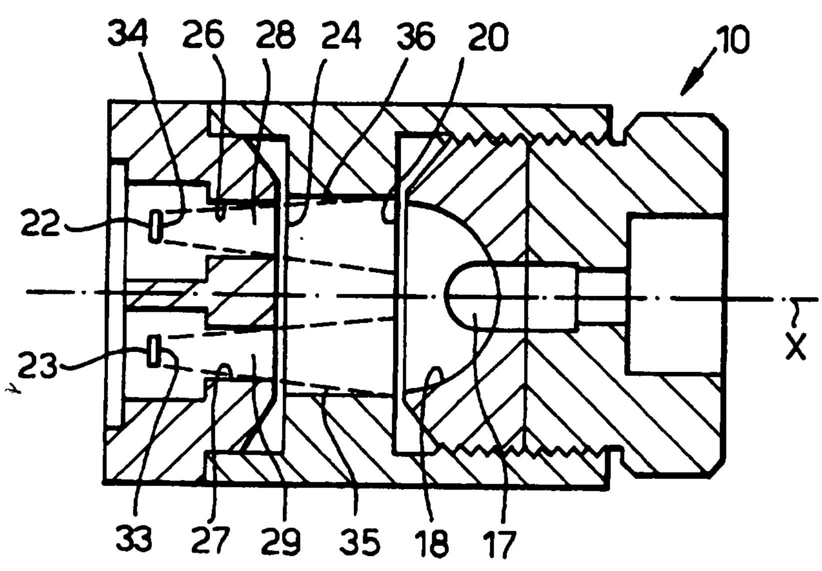
Fig.4.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IMPROVEMENTS IN OR RELATING TO GAS SENSORS

This invention relates to a non-dispersive radiation detection gas sensor and to a method of gas sensing.

Currently a gas concentration is detected using a light source, located at one end of a gas chamber, to transmit radiation through the chamber to a detector located at a remote and opposite end of the chamber. The detector monitors variations in the radiation intensity over specific wavelengths which correspond to those absorbed by a particular gas to be detected.

For example, a gas can be passed through the chamber and the radiation from the light source directed through the chamber. Gas within the chamber, according to its kind, absorbs radiation of a particular wavelength, absorption of the radiation causing radiation intensity to decrease at specific wavelengths. This decrease in intensity is monitored by the detector which is arranged to monitor variations in radiation intensity at the particular wavelength of interest.

In the prior art systems there is a problem with generating enough radiation from a light source to provide a usable signal at the detector. This problem has in part been overcome by radiation dispersive methods, wherein the radiation is caused to reflect off highly polished internal surfaces of the gas chamber. This results in a greater amount of radiation passing through the gas within the gas chamber.

The inventor has realised that although Beer's Law, a formula describing the intensity of radiation absorbed by a gas, is only truly valid for expensive monochromatic light sources such as Gas, Carbon Dioxide or Excimer lasers, it provides an approximation for non-monochromatic light sources used in prior art type gas sensors.

Beer's Law is given as:-

$$I = I_o e^{-\xi c l}$$

where ξ is the extension coefficient,

c is the molecular concentration of the gas,

l is the path length of the radiation through the gas chamber,

I_o is the reference radiation intensity, and

I is the intensity of the radiation after passing through the gas in the gas chamber over the distance l.

On application of Beer's Law to radiation dispersive devices, the path length, l, of radiation through the gas chamber, represents the summation of all possible radiation path lengths through the gas chamber including those radiation path lengths which reflect off the highly polished internal surfaces of the chamber.

The inventor has realised that a disadvantage of radiation dispersive methods, is that over time the highly polished internal surfaces of the chamber may degrade due to oxidation or deposition of material caused by the passing of gas through the chamber. The deposit causes the average radiation path length, l, to vary with time and a greater number of

erroneous readings to occur at the detector. The inventor has realised for Beer's Law to approximate a non-monochromatic light source over time the radiation path length, l must remain constant with time.

It is therefore an objective of the present invention to obviate or mitigate this disadvantage associated with the prior art.

According to a first aspect of the present invention there is provided a gas sensor, comprising a gas sensor, comprising

a gas chamber having an inner surface exposed to gas within the chamber,

a light source operative to irradiate gas within the chamber, and

an absorbance detector operative to receive radiation from the light source through gas within the chamber, wherein the absorbance detector is located behind the inner surface of the chamber and has associated therewith a passage extending towards the chamber, which passage limits the field of view of the absorbance detector, the passage being isolated from gas within the chamber by a window.

In this manner the field of view of the absorbance detector is limited to the light source by a passage which is isolated from gas, thereby the path length of light remains constant as deposits carried by the gas accumulate in the chamber.

The term light source in the context of the present specification including claims includes radiation wavelengths at the extremes of the visible spectrum, namely radiation such as infra-red and ultra-violet.

The passage may be arranged to substantially limit the field of view of the detector to the light source. The inner surface of the passage may be non-reflective. In this manner the absorbance detector only receives radiation emitted direct from the light source without reflection from the passage.

The light source may comprise a window that forms part of the inner surface of the chamber. A reflector may be arranged about the light source to focus radiation directly towards at least one detector.

The gas sensor may comprise two detectors, one of which is a reference detector having an associated passage that limits the field of view of the reference detector to the light source and the passage is isolated from gas within the chamber by a window. Each detector may be formed of a pyro-electric material or may be formed of a lead salt material.

Preferably, each passage may be isolated from gas within the chamber by a common window. The common window may be transmissive to radiation of selected wavelengths or alternatively, the common window may be transmissive to white light and each passage may comprise a respective difference filter associated with each detector. By using a

common window that is transmissive to white light the gas chamber is heated and condensation of gas within the chamber is mitigated.

Preferably, each passage is separated from gas within the chamber by respective different windows which are transmissive to different frequency bands.

The chamber may further comprise gas inlet and outlet passageways.

According to another aspect of the present invention there is provided a method of sensing gas, comprising passing gas through a gas chamber,

operating a light source to emit radiation and using the radiation to irradiate gas within the chamber,

providing a passage associated with the absorbance detector, forming the passage to limit the field of view of the absorbance detector to the light source, isolating the passage to prevent gas passing through the chamber coming into contact with the absorbance detector, and

detecting variations in intensity of the radiation received by the absorbance detector.

The invention is further described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a cross sectional view along a longitudinal axis of a first embodiment of a gas sensor, in accordance with the present invention;

Figure 2 illustrates a schematic end elevation of a detector housing of the gas sensor of Figure 1;

Figure 3 is a cross sectional view along a longitudinal axis of a second embodiment of a gas sensor, in accordance with the present invention, and

Figure 4 is a cross sectional view of a reduced capacity gas sensor illustrating limiting of the field of view of the detectors.

Referring to Figure 1, a gas sensor 10, comprises a housing 11 having a tubular gas chamber 12 extending co-axially along a longitudinal axis X of the housing 11. The chamber 12 has a gas inlet 13 and a gas outlet 14. The inner surfaces 15 of the chamber 12 are coated with a non-reflective layer, for example, with a matt black finish or alternatively, the housing 11 is constructed from a non-reflective material and the chamber 12 formed within the material to give non-reflective inner surfaces 15.

Arranged at one end of the chamber 12 is a light source housing 16 affixed to the housing

11. The light source housing 16 comprises a long life tungsten bulb 17 and a reflector 18 positioned to direct radiation emitted from the tungsten bulb 17, along the longitudinal axis X of the chamber 12, towards the remote and opposite end of the chamber 12 to form a radiation path 19.

The tungsten bulb 17 and reflector 18 are partitioned from the chamber 12 and thus any gas in the chamber 12 by a window 20 which allows selected wavelengths of radiation emitted from the bulb 17 to pass therethrough. The window 20 is formed from materials such as mica, quartz, germanium or saphire with an appropriate filter coating. The coating is selected such as to permit at least two frequencies or groups of frequencies of radiation to pass. One frequency, or group of frequencies, is selected which is absorbed by the gas to be sensed, hereinafter referred to as the absorbance frequency, whilst the other frequency, or group of frequencies, is selected which is close to the absorbance frequency but is not absorbed by the gas, hereinafter referred to as the reference frequency.

Arranged at the remote and opposite end of the chamber 12 to that carrying the light source housing 16, in alignment with the radiation path 19, is a detector housing 21 affixed to housing 11. The detector housing 21 comprises an absorption detector 22 and reference detector 23. Both of the detectors 22, 23 are arranged to face the radiation path 19 in alignment with the longitudinal axis X of the chamber 12.

The detectors 22,23 are partitioned from the chamber 12 and thus any gas passed through

the chamber 12 by a common window 24 which allows the radiation emitted from the bulb 17 to pass and to follow radiation path 19. The window 24 is formed of the same material as that of window 20 partitioning the bulb 17 and reflector 18 from the chamber 12. Radiation path 19 therefore extends substantially along the longitudinal axis X of the chamber 12, from the bulb 17 and reflector 18, towards the absorbance detector 22 and reference detector 23, and the radiation path 19 is substantially parallel to the inner surfaces 15 of the chamber 12.

In addition to the window 24, a further window 25 is positioned between the chamber 12 and the reference detector 23 which has a filter coating which blocks the absorbance frequency but does not attenuate the reference frequency.

To ensure that the radiation reaching the detectors 22, 23 along radiation path 19 is directly from the bulb 17 and reflector 18 with minimum radiation reflected from any of the inner surfaces 15 of the chamber 12, the detectors 22, 23 are recessed in detector housing 21 and are provided with radiation inhibitors 26, 27 comprising passages 28, 29 that extend towards the common window 24 which prevent radiation travelling at a reflected angle from reaching the recessed detectors 22, 23. As already mentioned the inner surfaces 15 of the chamber 12 are coated with a non-reflective layer or are constructed from non-reflective material which is used to prevent reflection of radiation off the internal surfaces 15, in the same manner surfaces of the passages 28, 29 can also be formed from or coated in a non-reflective material.

In Figure 2, there is shown detector housing 21 with the absorbance detector 22 mounted within mounting position 30 and its associated passage 28 forward of the absorbance detector 22. Also shown is reference detector 23 mounted within mounting position 31 and its associated passage 29 forward of the reference detector 23.

A number of fixing positions 32 are also provided for mounting a buffer circuit (not shown) to provide electrical connection to the detectors 22, 23. Mounting positions (not shown) are provided on the gas sensor 10 to provide fixing positions to a suitable base (not shown).

In operation, the radiation emitted from the bulb 17 is reflected along radiation path 19 by reflector 18, through the window 20 to irradiate any gas passing through the chamber 12. The radiation continues along radiation path 19, through window 24, into the passages 28, 29 and to each detector 22, 23. Substantially no radiation is reflected off the inner surfaces 15 of the chamber 12. Should reflected radiation be present in the chamber 12 it is prevented from reaching the detectors 22, 23 by passages 26, 27.

According to Beer's Law which is given as:-

$$I = I_o e^{-\xi c l}$$

Wherein, ξ is the extension coefficient, c is the molecular concentration of the gas, l is the path length of the radiation through the gas chamber, I_o is the reference radiation intensity, and I is the intensity of the radiation after passing through the gas in the gas chamber over

distance l.

Although Beer's Law only strictly holds true for monochromatic light sources since the extension co-efficient ξ, is dependent on the wavelength, it also holds sufficiently true for limited wavelengths employed with the present invention.

The extension coefficient (ξ) is deduced by empirical calculation, and the mean radiation path length (l) is also known, being equal to the direct path length along radiation path 19. The reference intensity (I_o) can, however, vary with time due to deposits on the windows 20, 24 laid by the gas passing through the chamber 12 and variations in the intensity of radiation emitted from the bulb 17. The value for the reference intensity (I_o) is obtained from the output of the reference detector 23, this output being dependent only on reference intensity (I_o) as it is not effected by the concentration (c) of the gas.

Given now that the values of radiation intensity (I) through an unknown gas, reference intensity (I_o), the radiation path length (l) and the extension coefficient (ξ) are all known, the molecular concentration (c) of the gas to be monitored for can be found by application of Beer's Law.

In Figure 3, the same reference numerals are used to indicate like parts in Figure 1. In this embodiment, window 33 allows white light to pass from the bulb 17 and reflector 18 along radiation path 19 to another window 34 which also allows wavelengths of white light to pass along radiation path 19.

Further windows 35, 36 are positioned between the chamber 12 and their respective detectors 22, 23. Window 35 allows wavelengths of radiation absorbed by the gas, passed through chamber 12, to pass to the absorbance detector 22 and window 36 allows wavelengths of radiation close to that absorbed by the gas, but which are not absorbed by the gas, to pass to the reference detector 23.

The use of white light radiation through the chamber 12 serves to provide greater energy to heat the optical components and thereby reduce the condensation on the optical components which come into contact with the gas passed through the chamber 12.

In Figure 4, there is shown a gas sensor 10 with a reduced capacity gas chamber 12, note that the gas inlet and gas outlet have been omitted for clarity and like references are used to identify like components previously described above. In this embodiment windows 20 and 24 are spaced closer together to provide less capacity within the gas chamber 12 thereby allowing a different concentration of the gas past through the chamber to be monitored. As shown the absorption detector 22 and reference detector 23 further comprise an active area 33, 34 that can receive light. Each active area 33, 34 and its associated radiation inhibitors 26, 27 are arranged to substantially limited the field of view 35, 36 of each active area 33, 34 to the bulb 17 and reflector 18.

It should be understood that the passing of gas through the chamber 12 can be a continuous process and a processor can be arranged to continuously provide the current value of molecular concentration (c). Depending on the application the reference detector

23 may only need to be used initially during set up of the sensor. Alternatively it can be used as a constant recalibration device.

The gas inlet and gas outlet can be replaced by slots or a series of holes which allow gas to diffuse through to the gas chamber for detection. The slots may be filled with a light tight material which allows gas to pass through to the chamber or the gas sensor may be surrounded by a light tight material to prevent light escaping from the chamber.

One embodiment of a gas sensor has been described above by way of example only, but it will be realised that the invention is equally applicable to various types and variations of gas sensors, which will be within the scope of the appended claims. In particular, the invention is equally applicable to gas sensors for monitoring for gas within their surroundings, i.e. of the type where the chamber is open to the ambient atmosphere.

CLAIMS

1. A gas sensor, comprising

a gas chamber having an inner surface exposed to gas within the chamber,

a light source operative to irradiate gas within the chamber, and

an absorbance detector operative to receive radiation from the light source through gas within the chamber, wherein the absorbance detector is located behind the inner surface of the chamber and has associated therewith a passage extending towards the chamber, which passage limits the field of view of the absorbance detector, the passage being isolated from gas within the chamber by a window.

2. A gas sensor, as in Claim 1, wherein the passage is arranged to substantially limit the field of view of the detector to the light source.

3. A gas sensor, as in Claim 1 or 2, wherein the inner surface of the passage is non-reflective.

4. A gas sensor, as in any preceding claim, wherein the light source comprises a window that forms part of the inner surface of the chamber.

5. A gas sensor, as in any preceding claim, wherein a reflector is arranged about the light source to focus radiation directly towards at least one detector.

6. A gas sensor, as in any preceding claim, comprising two detectors, one of which is a reference detector having an associated passage that limits the filed of view of the reference detector to the light source and the passage is isolated from gas within the chamber by a window.

7. A gas sensor, as in Claim 6, wherein each passage is isolated from gas within the chamber by a common window.

8. A gas sensor, as in Claim 7, wherein the common window is transmissive to radiation of selected wavelengths.

9. A gas sensor, as in Claim 7, wherein the common window is transmissive to white light and each passage comprises a respective different filter associated with each detector.

10. A gas sensor, as in Claim 6, wherein each passage is separated from gas within the chamber by respective different windows, which windows are transmissive to difference frequency bands.

11. A gas sensor, as in any preceding claim, wherein the chamber further comprises

gas inlet and outlet passageways.

12. A gas sensor substantially as illustrated and/or described with reference to the accompanying drawings.

13. A method of gas sensing, comprising

passing gas through a gas chamber,

operating a light source to emit radiation and using the radiation to irradiate gas within the chamber,

providing a passage associated with the absorbance detector, forming the passage to limit the field of view of the absorbance detector to the light source, isolating the passage to prevent gas passing through the chamber coming into contact with the absorbance detector, and

detecting variations in intensity of the radiation received by the absorbance detector.

14. A method of gas sensing substantially as illustrated and/or described with reference to the accompanying drawings.

Patent Office

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Application No: GB 9714922.3
Claims searched: 1-14

Examiner: Andrew Fearnside
Date of search: 20 October 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G1A (ACDD, ACDG, ADJA, ADJP, ADJX, ARU)

Int Cl (Ed.6): G01N 21/31, 21/33, 21/35, 21/37, 21/59, 21//61

Other: Online database: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	US4593197 (HORIBA, LTD) In particular col.2 and Fig.4.	1 - 14

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		